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ABSTRACT

This Cooperative Extension Service publication from Mississippi State University is a training guide for commercial applicators. Weed control, vertebrate pest control, and environmental considerations and restrictions are the three major parts of the document. The weed control section discusses non-pesticide, mechanical, and biological control as well as weed control in static water, large impoundments, flowing water, and limited-flow water ways. Both fish and mammal control practices are presented in the vertebrate pest control section. In the final section, application rates, state and federal regulations, units and conversion equivalents, and herbicide application formulas are presented. Also, an instrument of 26 true-false questions and 26 multiple choice items is included as "study questions." The answers are given. (MR)

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STUDY QUESTIONS ON THE MANUAL,
"AQUATIC PEST CONTROL"
TRAINING FOR CERTIFICATION OF COMMERCIAL APPLICATORS

True-False statements and multiple choice questions have been developed to help you review, study and better understand "Aquatic Pest Control." Answers are given at the end. Studying these questions will help you prepare for the written examination covering aquatic pests.

INSTRUCTIONS:

For the true-false questions, circle "T" if the statement is true and "F" if the statement is false.

The multiple choice questions have only one correct answer. Circle the letter of the correct choice.

TRUE-FALSE

T F 1. The first step in the control of aquatic weeds is to correctly identify the weeds.

T F 2. The abundance of aquatic plants and the use of the water in which aquatic plants grow, may determine whether the plants are considered weeds or desirable plants.

T F 3. Mechanical control of weeds in ponds and ditches is usually faster and cheaper than chemical control.

T F 4. Inorganic fertilizers added to ponds and small lakes to control weeds are more efficient in shallow water than in deep water.

T F 5. Liquid herbicide formulations are seldom used in the control of aquatic weeds.

T F 6. Proper design and construction of ponds so that there is very little water less than 2 or 3 feet deep is important in preventive control of many weeds.

T F 7. The advantage of using a herbicide in the form of an invert spray is that it will usually move great distances from the site of application.

T F 8. If you dissolve 2.7 pounds of any material in 1 acre-foot of water, there will be a concentration of 1 ppm.

T F 9. Generally only 1/4 to 1/3 of the surface area of a body of water should be treated at a time with a herbicide in order to protect fish from the possible hazard of oxygen depletion.

T F 10. The acre-feet of the total water column in a body of water is equal to the total surface acres of that body of water.

T F 11. Weeds in clear, static water may grow in water that is more than 15 feet deep.

T F 12. Control of aquatic weeds depends on good dispersion of the herbicide in the water.

T F 13. Liquid herbicides can be applied under the surface of the water by injection into the water from a boom mounted on a boat.

T F 14. Granular herbicides should be distributed unevenly under the water surface for best results.

T F 15. Wettable powder herbicides may be used to control submersed weeds and algae in static water.

T F 16. Liquid herbicides are most often applied as surface treatments, particularly in shallow water.

T F 17. The main use of granular herbicides is in the control of floating and emersed weeds.

T F 18. When herbicide pellets are used correctly, they make it possible to use some chemicals that would be toxic to fish in other formulations.

T F 19. The greater the area of the stream and the greater the velocity of flow, the smaller the volume of water that must be treated with a herbicide.

T F 20. When there is much water movement, weed control may be improved by selecting herbicides that are absorbed quickly by the weeds.

T F 21. Aquatic weeds in flowing water are usually the easiest to control.

T F 22. Liquid formulations of herbicides should never be applied directly to floating and emersed weeds with a boat, using various types of booms or spray guns.

T F 23. Copper sulfate is used to control algae, but it is toxic to trout at recommended treatment rates.

T F 24. You should always consider the possible contamination of water used for other purposes when you plan the use of herbicides in limited-flow waterways.

T F 25. Some birds, reptiles and amphibians may cause problems in local areas, but chemicals are rarely used to control them.

T F 26. All aquatic herbicides are very toxic to fish and other animal life, even at the concentrations recommended for weed control.

## MULTIPLE CHOICE

1. Effective control of aquatic pests may require which of the following control methods?
   A. Biological
   B. Chemical
   C. Mechanical and cultural
   D. (A) and (B)
   E. All of the above

2. Weeds that grow standing out of the water or in water-saturated soils are called:
   A. Emersed plants
   B. Exotic plants
   C. Hygroscopic plants
   D. Xerophytic plants

3. Which of the following plants is a floating aquatic plant?
   A. Bulrush
   B. Naiad
   C. Pithophora
   D. Waterhyacinth
   E. Watermilfoils

4. Chlorophyll bearing plants without true stems, leaves or vascular systems are:
   A. Fungi
   B. Algae
   C. Bacteria
   D. Ferns
   E. Slime molds

5. Pesticide chemicals used to control aquatic plants are classified as:
   A. Insecticides
   B. Acaricides
   C. Herbicides
   D. Piscicides
   E. Avicides

6. Which of the following herbicide formulations is rarely or never used in aquatic weed control?
   A. Emulsions
   B. Liquids
   C. Dusts
   D. Invert sprays
   E. Granules

7. A formulation consisting of an oil-soluble herbicide surrounded by a water carrier is called a(n):
   A. Bivert spray
   B. Emulsion
   C. Invert spray
   D. Granule

8. A formulation consisting of a water-soluble herbicide surrounded by an oil carrier is called a(n):
   A. Bivert spray
   B. Emulsion
   C. Invert spray
   D. Granule

9. To reduce the hazard to non-target organisms in deep water by keeping most of the herbicide near the bottom, herbicides are generally applied in the form of:
   A. Granules
   B. Wettable powders
   C. Emulsions
   D. Liquids

10. The surface acreage of a rectangular body of water equals length in feet times width in feet divided by:
   A. 54,360
   B. 45,650
   C. 43,560
   D. 56,430

11. If the toxicity level of a herbicide for a particular aquatic weed is 2 ppm of active ingredient, this means the herbicide should be applied at a ratio of 2 parts of active ingredient to how many parts of water?
   A. 98
   B. 1000
   C. 100,000
   D. 1,000,000

12. Multiplying the total surface acres of a body of water by the average depth in feet will give you what of that body of water?
    A. Weight
    B. Acre-feet
    C. Density
    D. Square feet
    E. None of the above

13. If you know that an acre-foot of water weighs 2.7 million pounds and want to treat a body of water containing 10 acre-feet, how many pounds of herbicide must you apply to the body of water to obtain a concentration of .2 ppm?
    A. 13.5
    B. 5.4
    C. 135
    D. 54

14. Static water is water in ponds, lakes or reservoirs that has little or no:
    A. Aquatic life
    B. Animal life
    C. Plant life
    D. Inflow and outflow

15. A herbicide may be dispersed throughout a body of water by:
    A. Wave action
    B. Thermal currents
    C. Diffusion
    D. (A) and (C)
    E. All of the above

16. Slow-release herbicide pellets are specially designed for the control of:
    A. Emersed weeds
    B. Floating weeds
    C. Submerged weeds
    D. (A) and (B)
    E. (B) and (C)

17. The main aquatic use of granular herbicides is in the control of:
    A. Emersed weeds
    B. Algae
    C. Submerged weeds
    D. (A) and (B)
    E. (B) and (C)

18. When applied correctly, the advantages of using slow-release herbicide pellets are:
    A. Easy to apply uniformly
    B. Can be applied with aerial equipment
    C. Fish can escape to the untreated surrounding water
    D. (B) and (C)
    E. All of the above

19. The possible hazards of herbicide use are greater in:
    A. Flowing water
    B. Static water
    C. Still water
    D. Stationary water

20. Pest fish are:
    A. Those that prey or feed upon more desirable fish
    B. Those that compete with more desirable fish for food, space and other necessities of life
    C. Those that affect man's interest or livelihood
    D. (A) and (B)
    E. All of the above

21. The use of chemicals to control unwanted fish species:
    A. Is a highly specialized area of pest control
    B. Is limited because few chemicals are registered for this purpose
    C. Always requires the temporary draining of bodies of water
    D. (A) and (B)
    E. All of the above

22. Damage caused by rodents might include:
    A. Burrowing, which structurally weakens earthen dikes, levees and dams; causes water losses or flooding; and increases erosion of banks
    B. Clogging of culverts or water pipe intakes with vegetation cut during feeding or nest-building activities
    C. Damming of streams
    D. (A) and (B)
    E. All of the above

23. Which of the following mammals are not rodents?
    A. Beavers
    B. Opossums
    C. Nutria
    D. Muskrats
    E. Rats

24. The control of aquatic vegetation presents special problems, because:
    A. All aquatic plants are weeds
    B. Waters often have multiple uses
    C. Herbicides are more efficient in deep water than in shallow water
    D. (A) and (B)
    E. (A) and (C)

25. Copper sulfate has been used for algae control in drinking water for many years and is permitted at the concentration of:
    A. 1 ppm copper ion
    B. 2 ppm copper ion
    C. 3 ppm copper ion
    D. 4 ppm copper ion
    E. No residue permitted at all

26. Correct application of herbicides to aquatic environments involves:
    A. Using excessive application rates
    B. Equipment calibration
    C. Calculation of appropriate water volumes
    D. (A) and (B)
    E. (B) and (C)

These fifty-two study questions were prepared by the Mississippi Department of Agriculture and Commerce, Division of Plant Industry, Mississippi State University.

ANSWEER SHEET
AQUATIC PEST CONTROL

TRUE-FALSE

1. T
2. T
3. F
4. F
5. F
6. T
7. F
8. T
9. T
10. F
11. T
12. T
13. T
14. F
15. T
16. T
17. F
18. T
19. F
20. T
21. F
22. F
23. T
24. T
25. T
26. F

MULTIPLE CHOICE

1. E
2. A
3. D
4. B
5. C
6. C
7. B
8. C
9. A
10. C
11. D
12. B
13. B
14. D
15. E
16. C
17. E
18. E
19. A
20. E
21. D
22. E
23. B
24. B
25. A
26. E

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## PREFACE

Federal regulations establish general and specific standards that you must meet before you can use certain pesticides. Your State will provide material which you may study to help you meet the general standards.

This guide contains basic information to help you meet the specific standards for applicators who are engaged in aquatic pest control. Because the guide was prepared to cover the whole nation, some information important to your State may not be included. The State agency in charge of your training can provide the other materials you should study. This guide will give you information about:

- recognition and control of aquatic pests, and
- environmental concerns in aquatic pest control

Your test for certification will be based upon:

- general information important to all commercial applicators, and
- specific information for aquatic pest control.

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# INTRODUCTION

The demand for water resources for recreational, agricultural, industrial, and other human purposes is increasing. Many kinds of aquatic pests, both plant and animal, can interfere with these and other water uses. Control or eradication of aquatic pests is of national importance as a means of protecting these uses for the public.

The information in this manual applies to control of aquatic pests in:

- recreational waters used for fishing, boating, and aquatic sports,
- agricultural reservoirs and water distribution channels used for stock-watering, irrigation, and drainage,
- ornamental ponds,
- coastal bays, estuaries, and channels, and
- drinking water reservoirs.

Effective control of aquatic pests requires the combination of all appropriate control methods, including:

- mechanical,
- cultural,
- biological, and
- chemical

## AQUATIC WEEDS

The first step towards prevention or control of aquatic weeds is to identify them correctly. Most control methods are aimed at specific weeds or at groups of weeds with similar growth habits. Aquatic weeds can be grouped as follows:

- Emersed aquatic weeds--weeds that grow standing out of the water, or in water-saturated soils. Examples are cattails, bulrushes, and arrowheads.
- Submersed aquatic weeds--weeds that grow under the water surface. Examples are pondweeds, naiads, coontails, and watermilfoils.
- Floating aquatic weeds--weeds that float on the water surface. Examples are duckweeds, waterhyacinth, waterlettuce, waterferns, and waterlillies.
- Algae--weeds without true stems, leaves, or vascular systems. Examples are waternet, pithophora, and chara.

Many of these plants may be pests in some situations and desirable plants in another, depending on:

- their abundance, and
- the use of the water they inhabit.

## WEED CONTROL

### Non-pesticide Control

Pond and Ditch Design--Proper design and construction of ponds is an important factor in preventive control of weeds. Shallow water at the margins of ponds provides an ideal habitat for emersed weeds, such as cattail. Submersed weeds can easily become established there and then spread into deeper

water. Banks should be sloped so that there is very little water less than 2 or 3 feet deep.

Proper design and construction of ditches and channels make weed control easier in the future. If the banks are leveled and smoothed, hard-to-reach places will be eliminated. Lining canals will help in alleviating water weed problems.

Mechanical Control--It may be necessary to use mechanical methods to control submersed weeds. Sources of water for drinking, for livestock, and for fish ponds often cannot be treated with chemicals.

. Chaining may be practical in some instances, particularly in canals.

. Drag lines are useful for cleaning canals and margins of lakes and ponds.

. Weed mowers are used in both canals and lakes for cutting weeds.

Some mowers simply cut the weeds loose beneath the water surface. Others (aquatic weed harvesters) collect the weeds for removal from the water.

Disposal of harvested weeds is frequently a problem. Most methods of mechanical control fragment the weeds. This may actually aid in the spread of most species of weeds, since they may reproduce from the fragments. Mechanical control is usually slower and more costly than control of the same weeds with chemicals.

Draining and Drying--Some ponds, lakes, canals, and ditches may be drained so aquatic weeds will dry. The water levels in some large lakes and reservoirs may be lowered enough to expose weeds in shallow areas. Drying periods of several months may be best for ponds or lakes. In canals, it may not be

practical to interrupt water flow for longer than 3 or 4 days. The season of year and species of plant present may determine whether this method will be useful in a particular situation.

Be sure to consider the resident fish species and their normal spawning times.

Fertilization--Fertilization with inorganic nutrients may be a convenient and inexpensive method of control of weeds in ponds and small lakes. Fertilization stimulates a dense bloom of microscopic algae. The algae shades the pond bottom and prevents or reduces the growth of rooted submersed weeds. Unless the fertilization is done correctly, the weed problem may become even more severe.

The fertilizer may be applied broadcast, applied from a boat, or dissolved in the water in other ways. Existing weeds either are not affected or their growth may be stimulated. You may need to remove them before fertilizing.

Ponds that have a monthly water exchange greater than the capacity of the pond do not respond well to fertilization. Fertilizers are more efficient in deep water than in shallow water.

Biological Control--Biological control is not often used. It has been successful in several situations, however.

Biological control agents include:

- Tilapia--This herbivorous fish has only limited value. It will eat aquatic plants and reproduce rapidly, but it survives winter temperatures in only a few very limited areas of this country.
- White amur--The white amur is a large fish that eats large amounts of aquatic vegetation. It survives well in all areas of the United States. Because it could become numerous enough to damage the aquatic environment, however, only a few States permit its use.

. Insects--Several insects have been brought into this country to control aquatic weeds. The most successful are a beetle and a moth that are parasitic on alligatorweed. They have provided good control of this weed in large areas of the South. Other insects are under study for control of other species of weeds.

Chemicals used in aquatic weed control are classified as herbicides. Herbicides used only, or primarily, for control of algae are often referred to as algaecides, even though they may also kill other aquatic plants.

Aquatic herbicides are available in several formulations.

Liquids--Some herbicides perform best when applied to water so that they disperse evenly and bathe the entire plant in the herbicide solution.

Granules--Others perform as well or better in the form of granules deposited on the bottom. Granules:

. carry the herbicide to plant roots, and

. reduce hazard to nontarget organisms in deep water by keeping most of the herbicide near the bottom.

Emulsions--Some herbicides not soluble in water are applied as emulsions.

Invert or Bivert Sprays--An invert is the opposite of an emulsion. In an emulsion, an oil-soluble herbicide is surrounded by a water carrier. In an invert, a water-soluble herbicide is surrounded by an oil carrier. When herbicides are in both the water and the oil the formulation is called a bivert.

Inverts may be used on

. ditchbank or floating aquatics, and

. submerged aquatics (including those in turbulent or slow-flowing water).

Inverts do not move far from the application site. Apply them directly to the area where control is needed.

Inverts may be mixed:

. in a tank before application, or

. at the time of application by feeding the ingredients through a small mixing blender.

Application Techniques

Three areas in the body of water may be treated:

. the surface,

. the total water column, or

. the bottom 1 to 3 feet.

Surface treatment--Generally only 1/4 to 1/3 of the surface area of the body of water is treated at a time. This protects fish from the possible hazard of oxygen depletion. Surface acreage of a rectangular body of water equals length in feet times width in feet divided by 43,560.

Total water column treatment--The whole body of water (from the bottom to the surface) is treated. Or you can treat 1/4 to 1/3 of the total water column (based on surface area) at a time. Calculate the volume of the body of water and add chemical to reach the required dilution in the total water column.

The amount of chemical needed to control or eradicate vegetation is often very small and is stated in parts per million (ppm).

If the toxicity level of a certain chemical for a particular aquatic weed is 2ppm of active ingredient, for example, the chemical should be applied at a ratio of 2 parts of active ingredient to 1 million parts of water in the area to be treated.

First, calculate the acre-feet of the body of water to be treated. Multiply surface acres by the average depth in feet. An acre-foot of water weight 2.7 million pounds. If one dissolves 2.7 pounds of any material in 1 acre-foot of water, there will be a concentration of 1 ppm. Use the following formula to determine the material needed to obtain a desired ppm concentration:

2.7 ppm wanted x acre-feet = lbs. required.

Assume one wants to treat a pond containing 10 acre-feet. The concentration of chemical required is .5 ppm. Using the formula: 2.7 x .5 x 10 = 13.5 lbs.

Bottom treatment--Bottom treatment is especially useful in deep water where it is impractical to treat the entire depth of water. Bottom treatments are generally made by attaching several flexible hoses at 3- to 5-foot intervals on a rigid boom. The hoses are usually equipped with some type of nozzle at the end. They may be weighted to reach the depth desired.

The length of hose and speed of the boat carrying the application equipment also affect the depth of application. Successful bottom treatments apply the herbicide as a blanket in the lower 1 to 3 feet of water.

Weed Control in Static Water

Static water is water in ponds, lakes, or reservoirs that have little or no inflow and outflow. Even totally enclosed bodies of water often have appreciable water movement because of wind and other conditions. Weeds commonly grow in static water up to 6 or 8 feet deep. In water of exceptional clarity, however, weeds sometimes grow in water 20 feet or more in depth.

Floating and Emersed Weeds

Liquid formulations are almost always recommended for floating and emersed weeds. These weeds require surface applications. The spray mixture can be applied directly to the plants:

. by aircraft,

. with ground equipment, if the pond is small, or if the weeds occur only around the margins, or

. by boat, using various types of booms or spray guns.

Submersed Weeds and Algae

Herbicide formulations for control of submersed weeds and algae in static water may be liquid, wettable powders or granules.

Liquid Formulations--Liquids are most often applied as surface treatments, particularly in shallow water. The herbicide is dispersed throughout the water by diffusion, thermal currents, and wave action. Liquid herbicides can be applied under the surface by:

. injection through a hose pulled along behind a boat, or

. injection into the water by booms.

In all instances, control of the weeds depends on good dispersion of the chemical in the water.

Bottom treatment with liquid herbicides may be used at times.

Liquid herbicides, may be applied from the air in low volumes. However, both surface and injection treatments made by boat or ground equipment are more effective and are easier when larger volumes of water are used. Most equipment for making applications by boat uses a special pumping system that draws water from the lake or pond. Concentrated herbicide is metered into the

pumped water to achieve the exact concentration required. These systems eliminate the need for frequent interruptions to prepare spray solution and the need to have large boats that carry water.

Granular Formulations--The main aquatic use of granular herbicides is in the control of algae and submersed weeds. Some are granules of pure chemical, such as copper sulfate. Others have a base of clay or other materials. Because granules sink to the soil surface, they may be used at times in deep water, where they perform about the same way as herbicides applied as bottom treatments. Application rates for granules may be based on:

. area, or

. the ppm concentration that would occur if the same amount of herbicide were dissolved and totally dispersed in the water.

Granules may be hand broadcast in small bodies of water. For large areas, use special granule spreaders mounted on aircraft or boat. For best results, distribute the granules evenly over the water surface.

Slow-release Pellets--Slow-release pellets are specially designed for the control of submerged aquatics. The pellets contain a herbicide plus an inert, slowly dissolving compound and binders. When a pellet contacts the water, it begins to disintegrate, slowly releasing small quantities of the herbicide over an extended period of time.

Treatment is usually confined to the bottom acre-foot, where the submerged weeds are. Fish can escape to the untreated surrounding water areas.

Advantages of slow-release pellets are:

. it is easy to apply the pellets uniformly, and

. they can be applied with aerial equipment.

Disadvantages are:

. A fine dust often accompanies the pellets. When inhaled for long periods, it can irritate the respiratory organs.

. If the pellets are not used with care (particularly when they contain fish-toxic chemicals) fish kills may result. However, when the pellets are used correctly, they make it possible to use some chemicals that would be toxic to fish in other forms.

Weed Control in Large Impoundments

Herbicide applications that are successful in smaller bodies of water often perform poorly in large impoundments, where there is often much water movement.

The movement is usually caused by thermal currents or the wind.

Weed control may sometimes be improved in these sites by:

. using the maximum recommended application rates,

. treating only a portion of the water area at one time,

. applying herbicides only during periods of minimum wind,

. using bottom treatments in deep water--pellets and inverts,

. using granular formulations when possible, and

. selecting herbicides that are absorbed quickly by the weeds.

Weed Control in Flowing Water

Aquatic weeds in flowing water are the most difficult to control. Because the water is moving from one location to others, the possible hazards of herbicide use is greater.

Herbicides are sometimes applied in treatment in natural streams. Control of aquatic weeds in man-made distribution and drainage systems is more common. Most of these carry irrigation water. Be sure there are no susceptible crops downstream. Some also carry domestic, industrial, and recreational water. As the number of water uses increase, more restrictions and precautions are required.

Floating and Emersed Weeds

These weeds, when in flowing water, require the same herbicides and treatment techniques as they do in static water. Precautions and restrictions are the same as those for control of submersed weeds in flowing water.

Submersed Weeds and Algae

Effective control of these weeds can be achieved in flowing water only by continuously applying enough herbicide at a given spot to maintain the needed concentration and contact time.

The greater the area of the stream and the greater the velocity of flow, the larger the volume of water that must be treated.

The large volume of water that must be treated makes the use of herbicides in flowing water costly, particularly when:

. the weed infestation covers only a small area, or

. the herbicides are effective for only a short distance downstream.

Few herbicides are recommended for control of submersed weeds in flowing water. The more common ones are:

. copper sulfate, used to control algae. It is toxic to trout at recommended treatment rates, but only moderately toxic to most other species. The toxicity of copper to fish increases with decreased alkalinity.

. aromatic solvent and acrolein, which are highly toxic to fish and many other forms of aquatic life. They are used primarily in water delivery systems that contain no fish, or where the water delivery is far more important than the value of the few fish that might be present.

Test treated water on a few seedlings of adjacent crops before using it for irrigation. Be sure that the treated water is all applied to cropland, or that the residues are at or below the levels permitted in other water.

Weed Control in Limited-Flow Waterways

Flood drainage canals, sloughs, and drains are good examples of limited-flow waterways. Weed control in these systems of little water movement is very similar to that used in static water. Consider the possible contamination of water used for other purposes when you plan the use of herbicides in limited-flow water. In some areas, drainage from these waterways eventually reaches water used in irrigation, or it may enter a fishery or drinking water supply.

VERTEBRATES

Fish

Some species of both marine and freshwater fish are considered pests in certain areas and situations.

The major kinds of pest fish are:

. those that compete with more desirable fish for food, space, and other necessities of life,

. those that affect man's interest or livelihood, and

. those that prey or feed upon more desirable fish.

## Control

The control of pest fish varies with each situation and species. Some problems are not serious enough to justify any action. In other situations, control is necessary and can be justified on sound biological grounds. Some pests may also be protected game fish, so control methods that do not harm the pest species may be the only legal solution.

Nonchemical control includes temporary draining of small bodies of water or using physical methods such as traps, net or screen barriers, or barrier dams.

Chemical control requires the use of pesticides. Few chemicals are registered for this purpose. The use of fish control chemicals is a highly specialized area of pest control. Use special care when applying them.

## Mammals

Rodents are of the most concern. They include:

- beavers,
- nutria,
- muskrats, and
- rats.

Damage includes:

- burrowing, which structurally weakens earthen dikes, levees, and dams; causes water losses or flooding; and increases erosion of banks,
- increasing suspended sediment in water,
- clogging culverts or water pipe intakes with vegetation cut during feeding or nest-building activities, and
- damming streams.

Control

Depending on the pest species and the situation, the following control methods may be used:

Nonchemical control, including:

. modifying or controlling habitat (such as controlling weeds to reduce food supplies),

. installing dike protectors or barriers,

. trapping, or

. shooting.

Chemical control, including the use of:

. repellents,

. fumigants, and

. baits.

Other Vertebrates

A few birds, reptiles, and amphibians may cause some problems in local areas. Chemicals are rarely used to control them.

ENVIRONMENTAL CONSIDERATIONS AND RESTRICTIONS

Incorrect application of herbicides in water may involve serious hazards to man, wildlife, fish and desirable plant life. Consequently, the applicator must be able to:

. select the correct herbicide for a specific aquatic site and particular weed infestation,

. apply it correctly at recommended rates,

. observe the restrictions on use of the treated water,

. be aware of the adverse effects of incorrect use, and

. obtain permission from appropriate State or Federal agencies.

The control of aquatic vegetation presents special problems, because:

. waters often have multiple uses, and

. herbicides will not always remain where they are placed.

Consider all the uses of the water to be treated, including those far downstream. Read the label to determine that the herbicide you choose is compatible with these uses.

Types of water uses to consider before applying herbicides include:

. human use, such as drinking, cooking, and swimming.

Few tolerances have been established for herbicide residues in water. Copper sulfate has been used for control of algae in drinking water for many years and is permitted at the concentration of 1 ppm copper ion. Limited residues of several other herbicides are permitted in raw drinking water. However, you should avoid contaminating any drinking water with any level of herbicide.

. livestock and wild animal use,

. irrigation,

. industry, and

. fish production--Most aquatic herbicides are not toxic to fish or other animal life at the concentrations recommended for weed control. Notable exceptions are emulsified aromatic solvents, acrolein and some derivatives of endothall surfactants in certain formulations of normally non-toxic herbicides. These should not be used in fisheries, or under circumstances that result in the entry of water treated with these herbicides into fishing waters.

It is possible to use these herbicides for treatment of small plots, or for treatment of weed-infested marginal areas with little hazard to fish. If given an avenue to escape, fish will leave areas where the herbicide is used. Trout are especially susceptible to copper sulfate. Trout waters should not be treated with copper sulfate without consulting fish biologists.

Application rates

Correct application of herbicides to aquatic situations involves equipment calibration and calculation of appropriate water volumes in order to determine correct dosage rates. Environmental hazard can result from the incorrect application rate.

Excessive application can cause:

. Damage to fish populations, either from direct toxicity, or from suffocation caused by an excessively rapid kill of plant materials, which may deplete the oxygen supply. The bacterial contamination resulting from decay of killed fish might further contaminate downstream water supplies.

. Exclusion of livestock from use of the water for a period of time.

. Making the water unfit for irrigation.

State and Federal Regulations

Many states have regulations which govern the use of pesticides in water. Check with the appropriate agency when in doubt. There are also stringent federal and some state regulations controlling the importation of exotic fish or plants.

Units and Conversion Equivalents

1 acre = 43,560 sq. ft.

1 acre-foot (A-ft.) = 43,560 cu.-ft. = 325,872 gal. = 2,720,000 lb. of water

1 cu.-ft. per second (cfs) = 450 gallons per minute (gpm)

1 cu.-ft. = 7.48 gal. = 62.4 lb. of water

1 gal. = 128 fluid ounces = 8.33 lb. of water

1 part per million of volume (ppmv) = 1 gal. per million gal. of water

1 part per million by weight (ppmv) = 8.33 lb. of chemical per million gal. of water

1 ppmv = 2.72 lb. of chemical per A-ft. of water

lb. ae or ai required

gal. of liquid formulation required = lb. ae or ai per gal. of concentrate

lb. of dry formulation required = $\frac{\text{lb. ae or ai required} \times 100}{\text{\% ae or ai by weight of formulation}}$

(ae = acid equivalent; ai = active ingredient)

Formulas for Herbicide Application to Channels

cfs = cross section area in sq. ft. x average velocity in ft. per second (fps)

Cross-section area of rectangular channel in sq. ft. = average width in feet times the average depth in ft.

$$\text{ppmv} = \frac{\text{gal. of chemical} \times 1{,}000{,}000}{\text{cfs} \times 450 \times \text{minutes applied}}$$

$$\text{gal. of chemical per cfs} = \frac{\text{ppmx} \times 450 \times \text{minutes applied}}{1{,}000{,}000}$$

$$\text{Total gal. of chemical required} = \frac{\text{ppmv} \times 450 \times \text{cfs minutes applied}}{1{,}000{,}000}$$

$$ppmw = \frac{\text{lb. of chemical} \times 1{,}000{,}000}{\text{cfs} \times 3744 \times \text{minutes applied}}$$

$$ppmw = \frac{\text{gal. of formulation} \times \text{lb. ae or ai per gal.} \times 1{,}000{,}000}{\text{cfs} \times 3744 \times \text{minutes applied}}$$

$$\text{lb. of chemical per cfs} = \frac{ppmw \times 3744 \times \text{minutes applied}}{1{,}000{,}000}$$

$$\text{gal. of formulation per cfs} = \frac{ppmw \times 3744 \times \text{minutes applied}}{\text{lb. ae or ai per gal.} \times 1{,}000{,}000}$$

Formulas for Herbicide Application to Ponds or Lakes

Volume of pond in cu.-ft. = surface area in sq. ft. x average depth in ft.

Volume of pond in A-ft. = surface area in acres x average depth in ft.

$$\text{Volume of pond in A-ft.} = \frac{\text{volume of pond in cu.-ft.}}{43{,}560}$$

$$ppmv = \frac{\text{gal. of 100\% active liquid chemical}}{\text{volume in A-ft.} \times 0.33}$$

Total gal. of chemical required = A-ft. x ppmv x 0.33

$$ppmv = \frac{\text{lb. ae or ai of chemical applied}}{\text{volume in A-ft.} \times 2.72}$$

Total lb. ai required = A-ft. x 2.72 x ppmw desired

$$\text{Total gal. of liquid formulation required} = \frac{\text{A-ft.} \times 2.72 \times ppmw}{\text{lb. ae or ai per gal. of concentrate}}$$